For the midterm exam,

1. Prepare for five or more blank papers, or note

2. Write down the problem number, your name and student number for each paper

3. If the exam gets started, you will have 10 min for each question.

4. After 10 min, please take a photo using the phone and email it to me

5. email : cyj@hanyang.ac.kr

Midterm Exam # 1

1. Prepare for blank paper

2. Write down the problem number and your name including student number

3. After 10 min, please take a photo using the phone and email it to me

Problem 1 (20pt) The following figure shows a table lamp that moves only in the plane of the page. Use Grübler's formula to calculate the number of degrees-of-freedom.
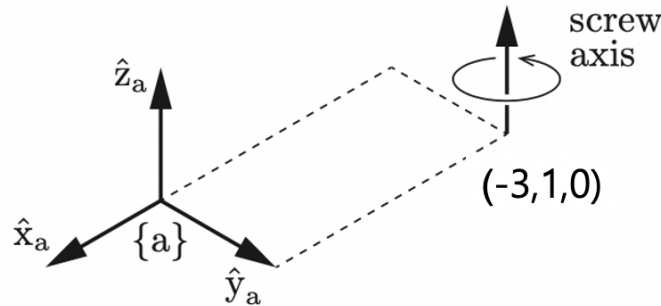
Midterm Exam # 2

1. Prepare for blank paper

2. Write down the problem number and your name including student number

3. After 10 min, please take a photo using the phone and email it to me

Problem 2 (20pt) The zero-pitch screw axis in the following figure, aligned with $\hat{z}_a$, passes through the point $(-3, 1, 0)$ in the $\{a\}$ frame. What is the twist $\mathcal{V}_a$ if we rotate about the screw axis at a speed $\dot{\theta} = 10[rad/s]$?

Midterm Exam # 3

1. Prepare for blank paper

2. Write down the problem number and your name including student number

3. After 10 min, please take a photo using the phone and email it to me

Problem 3 (20pt) The RRRP SCARA robot of the following figure is shown in its zero position. For $l_0 = l_1 = l_2 = 1$, determine the end-effector zero position configuration M and the screw axes $\mathcal{S}_i$ in $\{0\}$. Find the end-effector configuration $T_{0b} \in SE(3)$ when $\theta = (0, \frac{\pi}{2}, 0, 1)$.
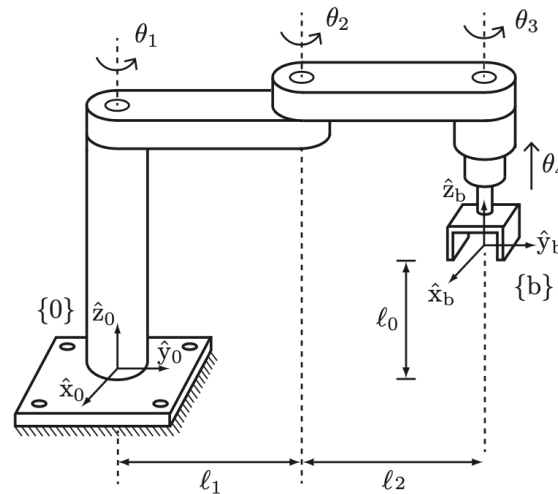

Figure 4.12: An RRRP SCARA robot for performing pick-and-place operations.
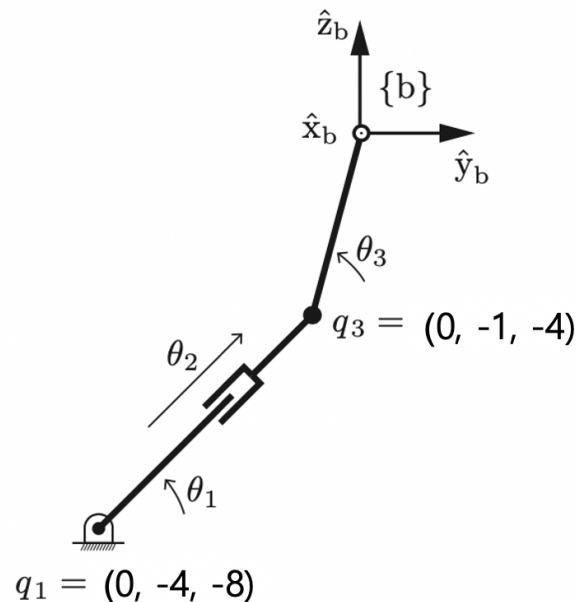
Midterm Exam # 4

1. Prepare for blank paper

2. Write down the problem number and your name including student number

3. After 10 min, please take a photo using the phone and email it to me

<u>Problem 4 (20pt)</u> The following figure shows an RPR robot that is confined to the plane of the page. An end-effector frame {b} is illustrated, where the $\hat{x}_b$-axis is out of the page. The directions of positive motion of the three joints are indicated by arrows. The axes of the two revolute joints are out of the page, and the prismatic joint moves in the plane of the page. Joint 1 is at $q_1 = (0, -4, -8)$ in {b} and joint 3 is at $q_3 = (0, -1, -4)$ in {b}. Write the body Jacobian $J_b(\theta)$ for the configuration shown. All entries of your $J_b(\theta)$ matrix should be numerical (no symbols or math).

Midterm Exam # 5

1. Prepare for blank paper

2. Write down the problem number and your name including student number

3. After 10 min, please take a photo using the phone and email it to me

<u>Problem 5 (20pt)</u> Find the joint velocities $\dot{\theta}$ minimizing the following index with $W = W > 0$.

$$\min \ \frac{1}{2}\dot{\theta}^T W \dot{\theta} + \dot{\theta}^T g(\theta) \qquad \textbf{subject to} \ \ \mathcal{V}_d = J\dot{\theta}$$